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INSTRUCTION MANUAL

MODEL 411, 411C

MICRO-MICROAMMETER

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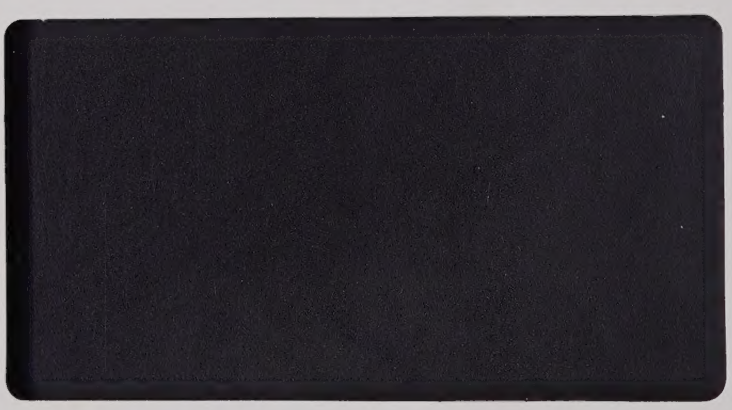
FACILITIES

KEITHLEY INSTRUMENTS



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INSTRUCTION MANUAL

MODEL 411, 411C

MICRO-MICROAMMETER

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SECTION I INTRODUCTION

Model 411

The Keithley Model 411 Micro-microammeter is a line operated vacuum tube electrometer designed and constructed especially for measuring small currents. Full scale ranges are from 10^{-3} to 10^{-11} ampere.

The features include full-scale voltage drop at the input of less than five millivolts, zero drift of less than 2% of full scale per week, good accuracy and calibration stability, and simplicity of operation. It also has an output which will drive a 0-1 or 0-5 milliampere recorder as well as the numerous potentiometer - rebalance recorders; one output terminal is at ground, making it convenient to connect cathode ray oscilloscopes or pen-driving amplifiers, similar to the Brush and Sanborn equipment.

The major panel controls are the range switch (amperes full-scale) and the zero. Minor controls are the Zero Check, used to short circuit the input and in setting the zero, Meter Polarity for providing up-scale readings for currents flowing in either direction, and an ON-OFF power switch. The meter dial is illuminated, and these bulbs serve as the pilot light.

Model 411C

The Keithley Model 411C is identical to the Model 411, except that the panel meter is provided with contacts which can be set to close at any predetermined meter pointer deflection. The delicate contacts of the meter operate a relay in the 411C, and the relay contacts (SPDT) are available for external switching functions through an AN connector on the rear of the chassis.

Response Speed, both models

THE 411 AND 411C ARE SHIPPED WITH CAPACITORS SHUNTING THE RANGE RESISTORS ON THE 10^{-8} THROUGH 10^{-11} AMPERE RANGES. THE CAPACITORS DAMP THE RESPONSE, LIMITING THE AMPLIFICATION OF SPURIOUS DISTURBANCES, AND PREVENTING OVERSHOOT AND RINGING WHEN A SQUARE PULSE OF CURRENT IS APPLIED AND INPUT CABLE CAPACITANCE IS AS MUCH AS 5000 MICRO-MICROFARADS. SUCH DAMPING IS USUALLY PREFERRED WHEN LONG INPUT CABLES ARE USED, AS WITH REMOTE ION CHAMBERS. WHEN MAXIMUM SPEED IS DESIRED, AS IN SOME PRODUCTION TESTS, AND VERY SHORT INPUT CABLES ARE BEING USED, THE CAPACITORS MAY SIMPLY BE REMOVED FROM THE RANGE SWITCH. SEE DETAILS ON PAGE II-2.

SECTION II DESCRIPTION

Seventeen overlapping current ranges, from 10×10^{-4} ampere to 10×10^{-12} ampere are selected by the Amperes Full Scale switch, located left of the Meter. The accuracy of the ranges from 10×10^{-4} through 10×10^{-8} is within 2%, 3×10^{-8} through 10×10^{-12} is within 4%.

Input Impedance is controlled by negative feedback from the output so that the voltage drop across the input terminals is less than 5 millivolts for full-scale meter deflection.

The Input Connector is located on the back face of the chassis. It is a UHF connector with teflon insulation, and accepts a standard teflon insulated mating plug. The plug and lead wires or cable should be extremely well insulated to prevent the leakage of the small currents. A cap is provided for keeping dirt out when the instrument is stored.

Input Switch Labelled ZERO CHECK is located to the left of the range switch. When depressed, it effectively shorts the input to remove spurious charges, and provides the zero input current reference for zeroing the meter with the Zero Control.

Grid Current is less than 5×10^{-14} ampere, and represents the limit of measurement of a vacuum tube electrometer. This is about 0.5% of full-scale on the most sensitive range.

Zero Drift is less than 2% of full scale per week on all ranges. This includes warmup from a cold start, provided the source voltage is 10 volts or more.

Zero Control - The Zero knob is located to the right of the meter and is used for zeroing the meter with zero input current. Effectively zero input current can be obtained by depressing the Zero Check button. The input must not be short-circuited. This upsets the negative feedback path and makes it impossible to zero the meter.

It is recommended that the meter pointer not be set anywhere but zero on the meter scale with zero input current, because with the feedback used, a dc potential is developed across the input whenever the output and the panel meter are not zero for zero input current. Recorders, of course, can be biased to any part of their scale for zero volts at the Model 411 output.

Output is provided for driving recorders. The amplifier will develop 10 volts for full-scale meter deflection, and 5 milliamperes can be drawn without upsetting the circuits. The OUTPUT connector is at the rear of the chassis. The connection details and suitable output attenuators are discussed in OPERATION, Section III.

Response Speed of the 411 depends upon the current range being used and also upon the capacitance of the external circuitry. On the less sensitive ranges the speed is limited by the amplifier response, which is from dc to approximately 1,000 cps. On the ranges from 3×10^{-7} to 10×10^{-11} amperes the speed has been reduced to about 1.0 second by the addition of capacitors across the range resistors. On the three most sensitive ranges, shunt capacitance across the input limits the response speed. Because of the method of application of the negative feedback, the slowing effects of capacitance from the high input terminal to ground have been greatly reduced, but are still significant. Table I below gives typical response speeds; viz; the time constant of the response to a step function.

TABLE I

TYPICAL RESPONSE SPEEDS

(to reach 67% of final value)

Ranges	with no significant external capacitance	with 5000 mmf across the input
1×10^{-11}	2.0 Seconds	4.0 Seconds
3×10^{-11}	1.0	2.0
1×10^{-10}	0.5	1.0
3×10^{-10}	0.5	1.0

If the maximum speed of response is desired, the capacitors shunting the range resistors may be removed; however the increased response to spurious ac signals may interfere with recording, and the transient response may suffer.

Amplifier Noise is principally power frequency, and is 50 millivolts rms max at the output terminals, irrespective of the current range. From the most general point of view, grid current and amplifier zero drift are also background noise; these have already been discussed.

Circuit Description

The circuit diagram DR 11175-C is enclosed at the back. The amplifier consists of two 5886 electrometer tubes operated as a balanced stage, with a substantial amount of in-phase rejection. Further in-phase rejection is obtained by supplying V1 and V2 screens from V3 and V4. A triode connected 6CM6 is used as the cathode follower output stage.

Negative feedback from the output is accomplished through the shunt resistor to the grid of the input electrometer tube. It is this feedback which keeps the input voltage drop low.

The open loop voltage gain of the amplifier, measured from the first stage grid to the feedback connection which would normally be connected to the low impedance end of the shunt resistor, is about 2500. This assures a low input drop.

To insure low drift, the feedback-voltage (the voltage drop across the high resistance range resistors) is made ten volts on all ranges.

The power supply is regulated by a Sola transformer. Half-wave selenium rectifiers supply the B+ and B- potentials. The filtering is conventional.

Calibration is determined by the value of the high resistance range resistors. From 10^{-3} to 10^{-7} amperes, the overall accuracy is better than 2%. From 3×10^{-8} to 10^{-11} amperes, the accuracy is better than 4%.

The meter is connected between the output terminal and ground. When the range resistor is shorted in zeroing the instrument, the meter measures the voltage existing between the input terminal and the output terminal (which are connected together when the shorting button is pressed) and ground.

The balancing of the amplifier, with the Zero control, is done in the filament circuit of V2. This is a convenient low-impedance point and does not disturb the electrode potentials of the low grid current electrometer tube.

SECTION III OPERATION

Simplicity of operation is an outstanding characteristic of the Model 411. First connect the input to a current source, and the output to a recorder or external indicator, if desired.

Then: a) Plug the power cord into a 110 volt 60 cps outlet. Note that because a Sola resonant regulating transformer is used, the power frequency, as well as voltage, must be the proper value.

b) Turn the amperes Full Scale to the 10×10^{-4} position.

c) Turn the power switch to ON.

d) After a few minutes warmup, set the panel meter to zero with the ZERO control.

e) Advance the instrument's sensitivity with the range switch, until a usable deflection is obtained on the panel meter. The current is read directly. Attention should be paid to the METER polarity switch, so that an up-scale deflection is obtained.

f) Periodically check the zero setting by operating the ZERO CHECK switch and rezeroing the meter if necessary.

Input, using cabling

The current source should be connected to the input connector with the high impedance side of the current source associated with central conductor of the connector. The lead-in cable should be polyethylene, polystyrene, or teflon insulated coaxial cable, and the connector should have teflon insulation. Amphenol type 83-756 or equivalent is recommended. During preparation of cable and connectors, it is essential that all high impedance surfaces be kept scrupulously clean to avoid leakage. With graphite coated cable, it is necessary to avoid tracking graphite onto the high impedance surfaces of the cut end of the insulation and the teflon surface of the connector. Movement of the cable during measurement should be avoided since this will cause spurious needle movements, because of capacitance changes and generation of static charges.

RECORDING: The Model 411 is provided with a connector on the rear of the chassis for recording. The output for full-scale meter deflection is ± 10 volts. The maximum current that may be drawn from the output terminals is 5 milliamperes. This output is suitable for driving one and five milliampere recorders as well as recorders employing an amplifier. Cinch-Jones S-202-B is the chassis connector, P-202-CCT is the mating plug. Terminal #1 is ground.

Table III gives resistance to be used in series with one and five milliampere recording milliammeters, to make the recorder full-scale deflection equal the panel meter full-scale deflection.

TABLE III

Recorder	Series Resistance
1 m.a.	8.3 to 8.7K
5 m.a.	1920 to 1940

The exact series resistance varies from recorder to recorder, and a portion of the series resistance should be adjustable so that the recorder may be calibrated exactly against the panel meter.

A suitable voltage divider for more sensitive recorders can easily be made, keeping in mind that 10 volts appear at the output terminals for full-scale deflection of the panel meter, and that a 2000 ohm divider will not draw too much output current and will be sufficiently low impedance to connect to amplifier inputs.

The Speed of Response, or the time constant of an input transducer and micro-microammeter, depends upon the speed of response of the circuitry of the instrument and also upon the capacitance of the current source and its connecting cable. Because of the way the negative feedback is applied in the Model 411, the external input capacitance is not nearly as important as in systems using a voltmeter across a shunting resistor, and quite large capacitances can be tolerated without having an impossibly slow response. Thus, a cable run from an ion chamber to the micro-microammeter is permissible.

The internal time constant of the Model 411 depends upon both the frequency response of the amplifier stages and the time constants of the high megohm range resistors and the associated distributed capacitances. These change from range to range on the 411, the speed decreasing as the sensitivity is increased. Table I in Section II, Description, gives quantitative values.

±216 Volts. A connector has been mounted on the back face of the chassis to provide ±216 volts for polarizing an ion chamber. The potential is derived from 2 0B2 voltage regulator tubes and is well filtered. The supply can be short circuited without damaging it. The chassis connector is Cinch-Jones S101, and P101 is the mating plug.

SECTION IV MAINTENANCE

The Keithley Model 411 Micro-microammeter has been designed to give long, trouble-free service. High quality components have been used throughout, and the circuits are stabilized by a substantial amount of negative feedback.

DR 11175-C, at the back, is the detailed circuit schematic diagram of the Model 411. The circuit operation was discussed in Section II, Description.

Maintenance Adjustments

One maintenance control is provided. It is accessible from the top of the chassis, and is located behind the meter.

R138, METER CALIBRATION, is in series with the Meter. To recalibrate, use the 10 x 10^{-4} range and, with 7 x 10^{-4} ampere through the input circuit, adjust R138 so the meter reads exactly 7.0. Since the shunt resistor on this range is accurate to 0.1% of its nominal value the overall accuracy can be adjusted to about 1% of full scale. On the 3 x 10^{-4} to 10 x 10^{-8} ampere range the range resistors are accurate to 1% and, providing the calibration was accurately done on the 10 x 10^{-4} range, the overall accuracy will be 2%. From 3 x 10^{-8} to 10 x 10^{-12} amperes the range resistors are accurate to 3% and the overall accuracy will be 4%.

Vacuum Tubes, V1 and V2, are the two electrometer tubes, and are located in an aluminum can which plugs onto the top of the chassis near the input terminals. The tubes have been selected, matched and labeled; V1 and V2 are Keithley part EV5886-8. It is recommended that the complete Input Tube Assembly, Model 4102, be kept for replacement purposes.

The other tubes are standard receiving tubes and need no special selection to assure satisfactory performance of the Model 411.

INSULATION: All insulation for the high impedance conductors is made of teflon, as are the contact insulators on the range switch. This should give satisfactory service in all humidities. Occasionally, the high impedance insulators should be inspected to insure that they are free from dirt and dust.

CONNECTOR CAP: The cap for the input connector should be kept in place whenever the connector is not being used. In storage and in transport, it keeps the insulation from accumulating dust and dirt. Before screwing the cap back onto the connector, be certain that it is clean, so the insulation will not be contaminated.

SECTION V SPECIAL INSTRUCTIONS FOR THE MODEL 411C

DR 11176-C is the circuit schematic diagram of the Model 411C. It differs from the 411 in providing the meter contacts, and the relay which is controlled by them.

The meter-relay is manufactured by Assembly Products, Inc. of Chesterland, Ohio, Model 461-C. Its contacts will close when the black meter pointer coincides with the red index pointer. The index can be set easily to any point on the meter scale by rotating the black knob on the front of the meter.

To obtain reliable contacting of the meter, the contacts are locked together electrically. Unlocking can be accomplished by operating the RESET button on the panel, or by a remote switch.

To complete the locking path, it is necessary that contacts A and B of the AN connector be connected. This can be done within the mating male plug, if resetting is to be done only with the panel button, or leads can be run to a remote reset relay or switch.

The one AN connector, it will be seen on the schematic diagram, is used for the resetting circuit, control relay contacts, and the output to a recorder.

The relay contacts are rated 5 amperes at 110 volts AC, or 24 volts DC.

Circuit Desig.	Description	Part No.
R-101	Resistor, WW, 10K. 1 W. 0.1%, Wire Leads	R18-16-10K
R-102	Resistor, Deposited Carbon, 33.3K. 1 W. 1%	R13-33.3K or R12-33.3K
R-103	Resistor, Deposited Carbon, 100K. 1 W. 1%	R13-100K or R12-100K
R-104	Resistor, Deposited Carbon, 333K. 1 W. 1%	R13-333K or R12-333K
R-105	Resistor, Deposited Carbon, 1 meg, 1 W. 1%	R13-1M or R12-1M
R-106	Resistor, Deposited Carbon, 3.33 meg. 1 W. 1%	R13-3.33M or R12-3.33M
R-107	Resistor, Deposited Carbon, 10 meg. 1 W. 1%	R13-10M
R-108	Resistor, Deposited Carbon, 33.3 meg. 1 W. 1%	R13-33.3M
R-109	Resistor, Deposited Carbon, 100 meg. 2 W. 1%	R14-100M
R-110	Resistor, Himeg, 3.33×10^8 ohms, 2%	R20-3.33×10^8
R-111	Resistor, Himeg, 10^9 ohms, 2%	R20-10^9
R-112	Resistor, Himeg, 3.33×10^9 ohms, 2%	R20-3.33×10^9
R-113	Resistor, Himeg, 10^{10}	R20-10^{10}
R-114	Resistor, Himeg, 3.33×10^{10} ohms, 2%	R20-3.33×10^{10}
R-115	Resistor, Himeg, 10^{11} ohms, 2%	R20-10^{11}
R-116	Resistor, Himeg, 3.33×10^{11} ohms, 2%	R20-3.33×10^{11}
R-117	Resistor, Himeg, 10^{12} ohms, 2%	R20-10^{12}
R-118	Resistor, Composition, 22M ohms, $\frac{1}{2}$ W. 10%	R1-22M
R-119	Resistor, ww, P.C., 12.5K 7W. 3%	R7-12.5K
R-120	Resistor, ww, 250 ohms, $\frac{1}{4}$ W. 1%	R18-6-250

REPLACEABLE PARTS LIST - MODEL 411 - 411-C

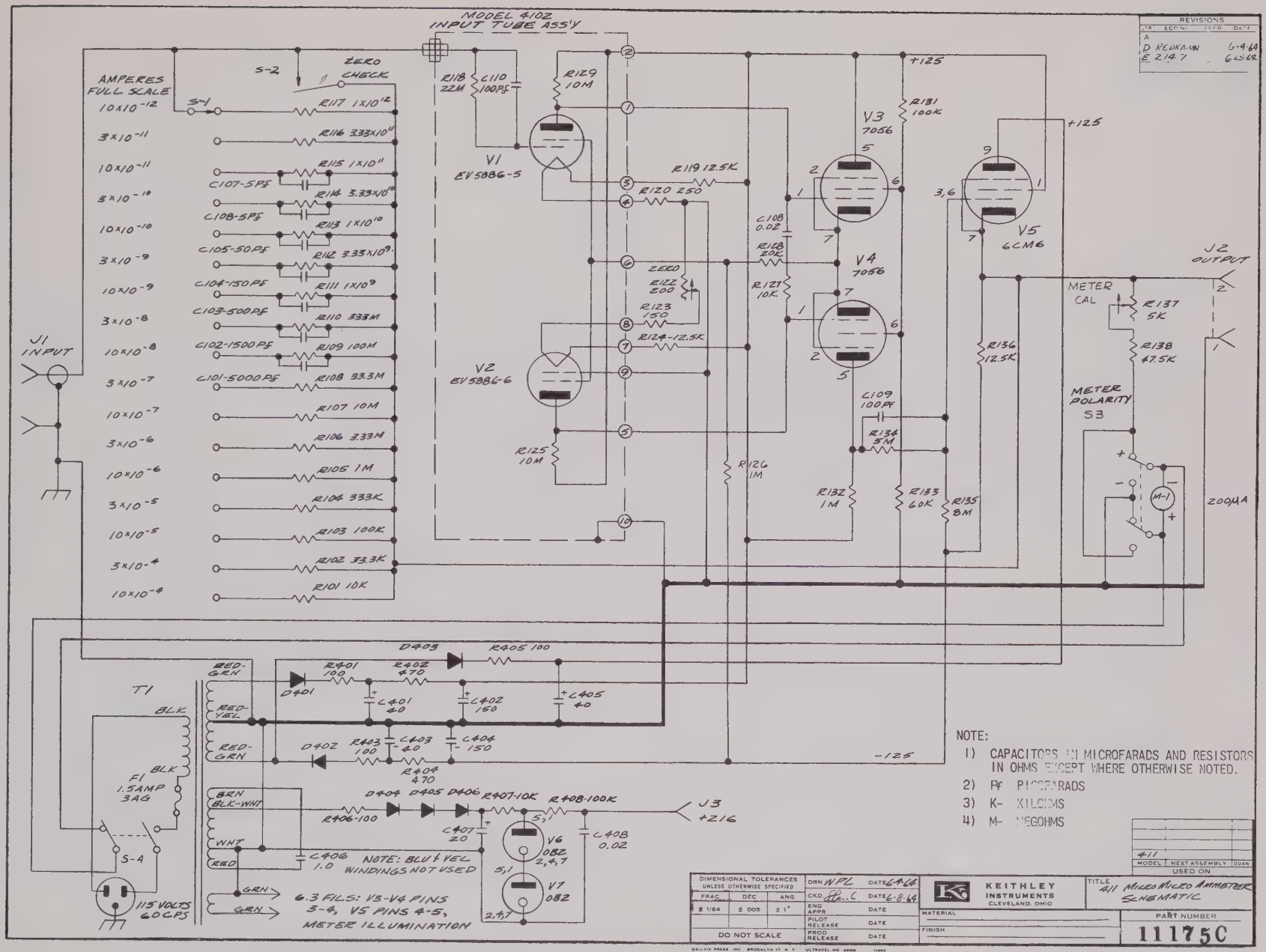
Circuit Desig.	Description	Part No.
R-122	Helipot, Type A, 200 ohms	RP-4-200
R-123	Resistor, WW. 150 ohms, $\frac{1}{4}$ W. 1%	R18-6-150
R-124	Same as R-119	
R-125	Same as R-107	
R-126	Resistor, Deposited Carbon, 1 meg. 1/3 W. 1%	R12-1M
R-127	Resistor, WW. P.C., 10K. 5 W. 3%	R4-10K
R-128	Resistor, Deposited Carbon, 20K, 1/3 W. 1%	R12-20K
R-129	Same as R-107	
R-131	Resistor, Deposited Carbon, 100K, 1/3 W. 1%	R12-100K
R-132	Same as R-126	
R-133	Resistor, Deposited Carbon, 60K. 1/3 W. 1%	R12-60K
R-134	Resistor, Deposited Carbon, 5 meg, 1 W. 1%	R13-5M or R12-5M
R-135	Resistor, Deposited Carbon, 8 meg, 1 W. 1%	R13-8M
R-136	Same as R-119	
R-137	Potentiometer, WW. 5K. 2 W. 1%	RP-3-5K
R-138	Resistor, WW. 47.5K. $\frac{1}{2}$ W. 1%, Wire Leads	R18-10-47.5K
R-401	Resistor, Composition, 100 ohms, $\frac{1}{2}$ W. 10%	R1-100
R-402	Resistor, Composition, 470 ohms, $\frac{1}{2}$ W. 10%	R1-470
R-403	Same as R-401	
R-404	Same as R-402	
R-405	Same as R-401	
R-406	Same as R-401	
R-407	Resistor, Composition, 10K ohms, $\frac{1}{2}$ W. 10%	R1-10K
R-408	Resistor, Composition, 100K ohms, $\frac{1}{2}$ W. 10%	R1-100K

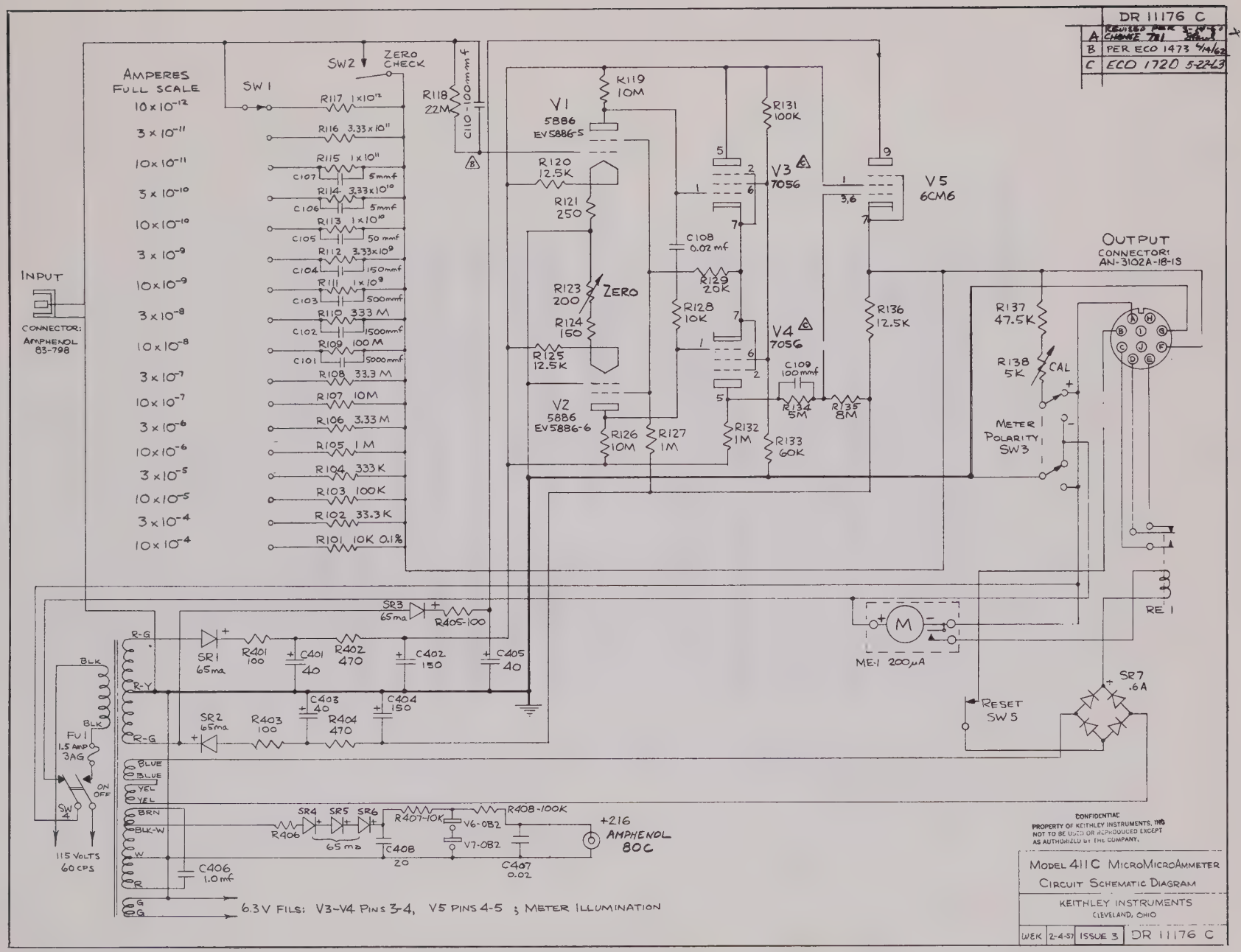
REPLACEABLE PARTS LIST - MODEL 411 - 411-C

Circuit Desig.	Description	Part No.
SR-1	Rectifier, Selenium 130 V. 65 ma	RF-18
SR-2	Same as SR-1	
SR-3	Same as SR-1	
SR-4	Same as SR-1	
SR-5	Same as SR-1	
SR-6	Same as SR-1	
SW-1	Range Switch	SW-30-17
SW-2	Switch, Push Button -- Zero Check	
SW-3	Switch, Toggle, DPDT	SW-14
SW-4	Same as SW-3	
T-1	Transformer, regulating -- Sola 71354	TR-17
V-1	Vacuum Tubes, 5886	EV-5886
V-2	Vacuum Tubes, 5886	EV-5886
V-3	Vacuum Tube, 6 CB 6	EV-6CB6
V-4	Same as V-3	
V-5	Vacuum Tube, 6 CM 6	EV-6CM6
V-6	Vacuum Tubes, OB 2	EV-OB2
V-7	Same as V-6	

REPLACEABLE PARTS LIST - MODEL 411 - 411-C

Circuit Desig.	Description	Part No.
C-101	Capacitor, Polystyrene 5000 mmf.	C31-5000
C-102	Capacitor, Polystyrene 1500 mmf.	C31-1500
C-103	Capacitor, Polystyrene 500 mmf.	C31-500
C-104	Capacitor, Polystyrene 150 mmf.	C31-150
C-105	Capacitor, Polystyrene 50 mmf.	C31-50
C-106	Capacitor, Polystyrene 5 mmf.	C31-5
C-107	Same as C-106	
C-108	Capacitor, disc, .02 mfd.	C22-0.02
C-109	Capacitor, disc, 100 mmf.	C22-100
C-110	Capacitor, disc, 100 mmf.	C22-100
C-401	Capacitor, Electrolytic, 40 mfd. 250 V.	C27-40
C-402	Capacitor, Electrolytic, 150 mfd. 150 V.	C9-150
C-403	Same as C-401	
C-404	Same as C-402	
C-405	Same as C-401	
C-406	Capacitor, 1.0 mfd.	Supplied with TR-17
C-407	Capacitor, Electrolytic, 20 mfd. 450 V.	C8-20L
C-408	Same as C-108	
FU-1	Fuse, 3 AG, 1.5 amperes	FU-8
ME-1	Meter, 200 uA, illuminated	ME-6
	The Following Items Used on MODEL 411-C Only	
ME-1	Meter, 200 uA, illuminated, Single Contact	ME-6C
RE-1	Relay, AP1 Series	RL-3
SR-7	Rectifier - .6 amperes	RF-7
SW-5	Switch, Push Button - Normally Closed	SW-35


MODEL 4102
INPUT TUBE ASS'Y
AMPERES FULL SCALE
S-1
S-2
ZERO CHECK
10x10⁻¹²
3x10⁻¹¹
10x10⁻¹¹
3x10⁻¹⁰
10x10⁻¹⁰
3x10⁻⁹
10x10⁻⁹
3x10⁻⁸
10x10⁻⁸
3x10⁻⁷
10x10⁻⁷
3x10⁻⁶
10x10⁻⁶
3x10⁻⁵
10x10⁻⁵
3x10⁻⁴
10x10⁻⁴
R117 1x10¹²
R116 3.33x10¹¹
R115 1x10¹¹
C107-5PF
R114 3.33x10¹⁰
C108-5PF
R113 1x10¹⁰
C105-50PF
R112 3.33x10⁹
C104-150PF
R111 1x10⁹
C103-500PF
R110 333M
C102-1500PF
R109 100M
C101-5000PF
R108 33.3M
R107 10M
R106 3.33M
R105 1M
R104 333K
R103 100K
R102 33.3K
R101 10K
J1 INPUT
R118 22M
C110 100PF
R129 10M
V1 EV5886-5
R119 12.5K
R120 250
R122 200
R123 150
R124 12.5K
V2 EV5886-6
R125 10M
R126 1M
V3 7056
V4 7056
V5 6CM6
+125
R131 100K
C108 0.02
R128 20K
R127 10K
C109 100PF
R134 5M
R132 1M
R133 60K
R135 8M
R136 12.5K
METER CAL
R137 5K
R138 47.5K
METER POLARITY S3
M-1
200MA
J2 OUTPUT
T1
BLK
RED-YEL
RED-GRN
BRN
BLK-WHT
WHT
RED
F1 1.5AMP 3AG
S-4
115 VOLTS 60CPS
GRN
D401
D402
D403
D404
D405
D406
R401 100
R402 470
R403 100
R404 470
R405 100
R406-100
R407-10K
R408-100K
C401 40
C402 160
C403 40
C404 150
C405 40
C406 1.0
C407 20
C408 0.02
V6 082
V7 082
NOTE: BLU & YEL WINDINGS NOT USED
6.3 FILS: V3-V4 PINS 3-4, V5 PINS 4-5, METER ILLUMINATION
-125
J3 +216
NOTE:
1) CAPACITORS IN MICROFARADS AND RESISTORS IN OHMS EXCEPT WHERE OTHERWISE NOTED.
2) PF- PICOFARADS
3) K- KILOHMS
4) M- MEGOHMS
REVISIONS
D REDRAWN 6-9-64
E 2147 6-15-64
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
FRAC ± 1/64 DEC ± .005 ANG ± 1°
DO NOT SCALE
DRN WPL DATE 6-4-64
CKD DATE 6-8-64
ENG APPR DATE
PILOT RELEASE DATE
PROD RELEASE DATE
KEITHLEY INSTRUMENTS CLEVELAND, OHIO
TITLE 411 MICRO-MICRO AMMETER SCHEMATIC
MATERIAL
FINISH
PART NUMBER 11175C
411 MODEL
NEXT ASSEMBLY
QUAN
USED ON


DR 11176 C
A CHANGE 711
B PER ECO 1473 4/4/62
C ECO 1720 5-22-63
AMPERES FULL SCALE
10 x 10⁻¹²
3 x 10⁻¹¹
10 x 10⁻¹¹
3 x 10⁻¹⁰
10 x 10⁻¹⁰
3 x 10⁻⁹
10 x 10⁻⁹
3 x 10⁻⁸
10 x 10⁻⁸
3 x 10⁻⁷
10 x 10⁻⁷
3 x 10⁻⁶
10 x 10⁻⁶
3 x 10⁻⁵
10 x 10⁻⁵
3 x 10⁻⁴
10 x 10⁻⁴
SW1
SW2 ZERO CHECK
R117 1x10¹²
R116 3.33x10¹¹
R115 1x10¹¹
C107 5mmf
R114 3.33x10¹⁰
C106 5mmf
R113 1x10¹⁰
C105 50 mmf
R112 3.33x10⁹
C104 150mmf
R111 1x10⁹
C103 500mmf
R110 333 M
C102 1500mmf
R109 100 M
C101 5000mmf
R108 33.3 M
R107 10M
R106 3.33 M
R105 1 M
R104 333K
R103 100K
R102 33.3K
R101 10K 0.1%
R118 22M
C110 100mmf
INPUT
CONNECTOR: AMPHENOL 83-798
V1 5886 EV5886-5
V2 5886 EV5886-6
V3 7056
V4 7056
V5 6CM6
R119 10M
R120 12.5K
R121 250
R123 200 ZERO
R124 150
R125 12.5K
R126 10M
R127 1M
R128 10K
R129 20K
R131 100K
R132 1M
R133 60K
R134 5M
R135 8M
R136 12.5K
R137 47.5K
R138 5K CAL
C108 0.02 mf
C109 100mmf
METER POLARITY SW3
OUTPUT CONNECTOR: AN-3102A-18-1S
RE 1
M
ME-1 200μA
RESET SW5
SR7 .6A
SR1 65ma
SR2 65ma
SR3 65ma
R401 100
R402 470
R403 100
R404 470
R405-100
C401 40
C402 150
C403 40
C404 150
C405 40
R-G
R-Y
BLK
BLUE
YEL
BRN
BLK-W
W
R
G
FU1 1.5 AMP 3AG
SW4 ON OFF
115 VOLTS 60 CPS
C406 1.0mf
SR4 SR5 SR6
R406
R407-10K
R408-100K
V6-082
V7-082
C408 20
C407 0.02
+216 AMPHENOL 80C
6.3 V FILS: V3-V4 PINS 3-4, V5 PINS 4-5 ; METER ILLUMINATION
CONFIDENTIAL
PROPERTY OF KEITHLEY INSTRUMENTS, INC
NOT TO BE USED OR REPRODUCED EXCEPT AS AUTHORIZED BY THE COMPANY.
MODEL 411C MICROMICROAMMETER
CIRCUIT SCHEMATIC DIAGRAM
KEITHLEY INSTRUMENTS
CLEVELAND, OHIO
WEK 2-4-57 ISSUE 3 DR 11176 C

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof (except tubes and batteries) which, within a year after shipment, proves defective upon examination.

To exercise this warranty, contact your Keithley field engineering representative. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments and its international distributors maintain complete repair facilities.

To insure prompt repair or recalibration service, please contact your Keithley field representative before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

CHANGE NOTICE

March 15, 1965

MODELS 411, 411C MICRO-MICROAMMETERS

Replaceable Parts List. Change to the following:

C101	Capacitor, Polystyrene, 5000 pf	C138-5000P
C103	Capacitor, Polystyrene, 510 pf	C138-510P
C105	Capacitor, Polystyrene, 47 pf	C138-47P

Schematic Diagrams 11175C and 11176C.

Change the values of C103 and C105 to 510P and 47P, respectively.

KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE CLEVELAND, OHIO 44106